THERMALLY COMPENSATED SILICON PRESSURE SENSOR

BACKGROUND OF THE INVENTION

The present invention relates to semiconductor pressure sensors and specifically to such sensors which employ the piezoresistive effect of single crystal silicon structures. The basic semiconductor pressure device of the prior art includes a diaphragm portion, having one or more silicon resistor elements of a desired type conductivity, which flexes when a pressure differential is applied across the diaphragm. This diaphragm portion of the pressure sensor is surrounded by a clamp ring portion around the entire perimeter of the diaphragm portion. This clamp ring portion is much thicker and by providing mechanical stability for the pressure sensor enables rigid mechanical connection to the pressure sensor. This silicon pressure sensor is disposed in a housing which enables the production of a pressure differential across the faces of the diaphragm portion. The flexure of the diaphragm portion due to this pressure differential is measured via the change in resistance of the doped resistive element or elements of the diaphragm portion. This resistive change is due to the stress of the diaphragm flexure and is called the piezoresistive effect. Pressure sensors of this type have been described in a Gieles, A. C. M. and G. H. Somers "Miniature Pressure Transducers with a Silicon Diaphragm", Phillips Technical Review, 33, pages 14 through 20, 1973. One problem with silicon pressure transducers of this type is that the piezoresistive elements display resistive changes with temperature as well as the resistive changes with the flexure of the diaphragm.

SUMMARY OF THE INVENTION

The present invention involves a silicon pressure sensor of the type described above which further includes a temperature sensor disposed upon the same chip. This temperature sensor enables compensation for the temperature dependent resistive change in the piezoresistive sensing element.

One aspect of the present invention is embodied in a thermally compensated silicon pressure sensor comprising a single crystal of silicon having a diaphragm portion of a first type conductivity having a thickness permitting flexure when a pressure differential is applied thereacross and having one or more resistor elements of the opposite type conductivity disposed therein in a position for exhibiting piezoresistivity when the diaphragm is flexed and further having a clamp ring portion disposed around the entire perimeter of the diaphragm portion having a thickness permitting virtually no flexure and having a temperature sensitive resistor element disposed therein.

A further embodiment of the present invention comprises a thermally compensated silicon pressure sensor such as described above in which the one or more resistor elements comprise a continuous loop resistor element formed into a Wheatstone bridge in which each resistor element of a first pair of opposite arms of the Wheatstone bridge is disposed in a central portion of the diaphragm portion and in which each resistor of a second pair of opposite arms of the Wheatstone bridge is disposed in a peripheral portion of the diaphragm portion, further having electrical terminals disposed in ohmic contact with the continuous loop resistor element thereby defining the respective arms of the Wheatstone bridge.

A still further embodiment of the present invention comprises a thermally compensated silicon pressure sensor such as described above in which the temperature sensitive resistor element is a spreading resistance thermistor such as disclosed in U.S. Pat. No. 3,936,789, issued to Matzen et al, Feb. 3, 1976, and which is assigned to the same assignee of the present application.

Yet another embodiment of the present invention comprises a thermally compensated silicon pressure sensor having a silicon carbide diaphragm layer with one or more piezoresistive elements disposed thereon, having a polycrystalline silicon clamp ring and having a temperature sensitive resistor element disposed on the silicon carbide layer where it is supported by the clamp ring.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and further objects and embodiments of the present invention will become clear in the following detailed description of the invention taken in conjunction with the drawings in which:

FIG. 1 is a perspective view of one embodiment of the present invention;

FIG. 2 is a perspective view of a cross section of the embodiment illustrated in FIG. 1 taken along the line A—A'.

FIG. 3 is a perspective view of a cross section of a second embodiment of the present invention;

FIG. 4 is a perspective view of a cross section of a second embodiment of the temperature sensitive resistor;

FIG. 5 is a perspective view of a cross section of a third embodiment of the present invention;

FIG. 6 is a cross sectional view of the structure illustrated in FIG. 1 illustrating diaphragm flexure; and

FIG. 7 is a block diaphragm of a microprocessor external temperature compensation circuit for use with the pressure sensor of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As illustrated in FIG. 1, the temperature compensated pressure sensor **100** of the present invention comprises two main portions, diaphragm portion **110** and clamp ring portion **120**. The entire pressure sensor **100** including diaphragm portion **110** and clamp ring portion **120** is fashioned from a single silicon crystal. One part of the crystal is etched out in a manner which will be described more fully below to produce a thin, flexible diaphragm portion **110**. This diaphragm portion **110** and the clamp ring portion **120** have impurities added thereto in order to obtain a semiconductor of a first type conductivity. Disposed in the diaphragm portion **110** are resistor elements **111**, **112**, **113** and **114** which are composed of semiconductor material of the opposite type conductivity. These resistor elements **111** to **114** are formed by implanting or diffusing the opposite type conductivity impurities into these sections of the diaphragm according to known techniques. Also disposed upon diaphragm portion **110** are metal contacts **115**, **116**, **117** and **118**. Preferably, resistor elements **111** to **114** include contact tabs (not illustrated) provided for connection to metal contacts **115** to **118**. These metal contacts are disposed on top of the pressure sensor **100** in any manner known in the art so that they are in ohmic